REPORT No. 357

AIRCRAFT ACCIDENTS

METHOD OF ANALYSIS

Report Prepared by Committee
on Aircraft Accidents

LETTER OF SUBMITTAL

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS,
Washington, D. C., January 28, 1930.

GENTLEMEN: The Committee on Aircraft Accidents, organized on October 3, 1928, to continue the work begun by the Special Committee on the Nomenclature, Subdivision, and Classification of Aircraft Accidents, has made a careful study of aircraft accidents in accordance with the method of analysis prepared by the special committee and published as Technical Report No. 308 of the National Advisory Committee for Aeronautics. This study has included in particular the underlying causes of pilots' errors, especially the physiological causes; the large number of spins and stalls resulting in fatal accidents; and a comparison of the types of accidents and causes of accidents in the military services on the one hand and in civil aviation on the other.

As a result of this study it was deemed desirable that the committee prepare a revision of Technical Report No. 308, clarifying a number of the definitions in the light of the experience gained in the classification of accidents in the War, Navy, and Commerce Departments.

There is attached hereto a copy of the revised report on "Aircraft Accidents—Method of Analysis," which includes the accident analysis chart and definitions prepared by the Special Committee on the Nomenclature, Subdivision, and Classification of Aircraft Accidents, with a number of the definitions clarified; a brief statement of the organization and work of the special committee and of the Committee on Aircraft Accidents; and statistical tables giving a comparison of the types of accidents and causes of accidents in the military services on the one hand and in civil aviation on the other, together with explanations of some of the important differences noted.

In accordance with resolution adopted at a meeting of the Committee on Aircraft Accidents held on January 17, 1930, I have the honor to recommend that the attached report be published as a Technical Report of the National Advisory Committee for Aeronautics, to supersede Technical Report No. 308.

Respectfully,

COMMITTEE ON AIRCRAFT ACCIDENTS,
GEORGE K. BURGESS, *Chairman.*

The EXECUTIVE COMMITTEE,
National Advisory Committee for Aeronautics,
Washington, D. C.

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INTRODUCTION

PURPOSE AND HISTORY

This report is a revision and expansion of the report prepared by the Special Committee on the Nomenclature, Subdivision, and Classification of Aircraft Accidents, which was issued as Technical Report No. 308 of the National Advisory Committee for Aeronautics. The special committee was organized by the National Advisory Committee for Aeronautics in response to a request dated February 18, 1928, from the Air Coordination Committee, which consists of the Assistant Secretaries for Aeronautics in the Departments of War, Navy, and Commerce. The request of the Air Coordination Committee was made "in order that practices used may henceforth conform to a standard and be universally comparable." The task of the special committee was, therefore, to prepare a basis for the classification and comparsion of aircraft accidents, both civil and military.

The special committee was organized in pursuance of resolution adopted by the Executive Committee of the National Advisory Committee for Aeronautics on March 1, 1928, and held its initial meeting on March 19, 1928. Sixteen meetings were held, the last being on July 17, 1928. In its final meeting, this special committee unanimously adopted a resolution approving its report, and recommending that it be published by the National Advisory Committee for Aeronautics and that copies be transmitted to the War, Navy, and Commerce Departments with a recommendation that the proposed method of analysis of aircraft accidents outlined in the report be adopted for use in their respective services. The special committee also recommended that copies of the report be transmitted to the appropriate representatives of the various interested foreign governments, with a request that they cooperate by contributing information from time to time in relation to aircraft accidents.

With the submission of its report, the special committee stated that it believed its work to be concluded and that it should be discharged. It was believed, however, that the introduction of the proposed method for the analysis of accidents would result in questions as to interpretation and suggestions for changes, many of which it was believed had been considered during the meetings of the committee. It was also thought probable that a study of the information obtained from the application of the method of analysis would indicate that certain features of aircraft construction or operation should be given more detailed study or consideration. The committee, therefore, adopted a resolution recommending that its personnel should be reorganized into a standing Committee on Aircraft Accidents of the National Advisory Committee for Aeronautics for the purpose of considering from time to time such new matter as might appear desirable, or as might be brought before it.

In accordance with this recommendation a Committee on Aircraft Accidents was authorized by the Executive Committee of the National Advisory Committee for Aeronautics by resolution adopted on October 3, 1928. This committee held its first meeting on March 16, 1929, and has held meetings since that date.

ORGANIZATION

The original organization of the standing committee was as follows:

Representatives of the National Advisory Committee for Aeronautics:
Dr. George K. Burgess, Chairman.
Mr. George W. Lewis.
Representatives of the Army Air Corps:
Lieut. D. B. Phillips, U. S. A.
Lieut. J. D. Barker, U. S. A.
Representatives of the Bureau of Aeronautics of the Navy:
Lieut. Commander L. C. Stevens (C. C.), U. S. N.
Lieut. Charles R. Brown, U. S. N.
Representatives of the Aeronautics Branch, Department of Commerce:
Mr. Edward P. Howard.
Mr. Lester T. Bradbury.

Owing to changes in stations of its military members and other causes, the membership of the committee has altered in the last year, and at the present time it is as follows:

Representatives of the National Advisory Committee for Aeronautics:
Dr. George K. Burgess, Chairman.
Mr. Edward P. Warner.
Mr. George W. Lewis.

Representatives of the Army Air Corps:
Lieut. Harold Brand, U. S. A.
Lieut. L. P. Whitten, U. S. A.
Representatives of the Bureau of Aeronautics of the Navy:
Lieut. Commander L. C. Stevens (C. C.), U. S. N.
Lieut. Stanhope C. Ring, U. S. N.
Representative of the Aeronautics Branch, Department of Commerce:
Mr. W. Fiske Marshall.

COOPERATION OF MEDICAL BRANCHES AND OTHERS

The part that physiological and psychological causes play in aircraft accidents has been appreciated from the beginning of the work by the special committee. Representatives of the medical branches of all three services have attended the meetings of the committee and have participated in the discussions with considerable regularity. On June 29, 1929, a meeting was held which was devoted chiefly to the discussion of the physiological and psychological factors of accidents.

The committee believes that the presence of the representatives of the medical services has been most helpful and has assisted in the placing of more accurate values on many of the factors involved in its study of aircraft accidents. In addition, it is hoped that in the course of their cooperation with the committee its medical associates have been afforded a useful opportunity for the discussion of their common problems. Certainly the members of the committee have gained in appreciation and respect for these problems.

In addition to the members of the committee, the following have assisted in the work of the committee:

Representative of the Army Air Corps:
Lieut. Col. L. M. Hathaway (M. C.), U. S. A.
Representatives of the Navy:
Commander R. G. Davis (M. C.), U. S. N.
Lieut. Commander J. R. Poppen (M. C.), U. S. N.
Representatives of the Aeronautics Branch, Department of Commerce:
Dr. L. H. Bauer.
Dr. H. J. Cooper.
Mr. P. Edgar.
Mr. F. J. Martel.
Mr. E. R. Strong.
Representative of the National Advisory Committee for Aeronautics:
Mr. Starr Truscott.

CHANGES IN ORIGINAL REPORT

As a result of experience in the use of the method originally proposed in Technical Report No. 308, certain changes in the definitions and the explanatory matter have become desirable. These are not radical and do not seriously alter any part. The most notable is the introduction of a new class N "Structural Failure" under Nature of Accidents, and the changing of former classes L and M to X and Y, respectively. The "Description and Typical Analysis of an Accident" has also been expanded somewhat for the sake of increased clearness.

GENERAL CONSIDERATIONS

DEFINITION OF AN AIRCRAFT ACCIDENT

An aircraft accident is an occurrence which takes place while an aircraft is being operated as such and as a result of which a person or persons are injured or killed or the aircraft receives appreciable or marked damage through the forces of external contact or through fire. A collision of two or more aircraft should be analyzed and reported statistically as one accident. It is appreciated that in some cases, as where a collision involves two aircraft of different squadrons or different services, it will necessarily appear in two separate accident reports and that a certain amount of duplication in tabulation will inevitably be involved. In such a case each service or unit involved will credit to its own account only those personnel injuries or fatalities occurring in the aircraft for which it is individually responsible.

AIRCRAFT ACCIDENT ANALYSIS FORM

In drawing up the aircraft accident analysis form and the accompanying definitions the committee had in mind the frequency rate of accidents from the various causes, the logical lines along which studies should be conducted, and the ease with which these studies can be made from this chart. It is recognized that to make a detailed study of accidents due to any one cause a further subdivision may be necessary. However, if all accidents are classified according to this chart the major causes can be easily determined and further investigation can be readily carried out for the purpose of eliminating these causes.

It was also recognized, in working out this chart, that the division of immediate causes between personnel and matériel as set forth in the chart and definitions was more or less arbitrary, since all defects of aircraft can in the last analysis be attributed to errors of personnel, whether in operation, inspection, maintenance, manufacture, or design. Since the purposes of the accident study seemed to be best served by drawing attention to defects of matériel, even though traceable ultimately to personnel errors, the line between personnel and matériel in the immediate causes was drawn at the operating personnel of the aircraft. In other words, under the main heading "Personnel" there are included only those accidents for which personnel engaged in operating the aricraft are responsible. Accidents due to matériel failure are classified under "Matériel" even though personnel charged with design, construction, or operation may be held resonsible for the failure. Errors due to personnel other than those immediately accessory to the operation of the aircraft are shown in the "Underlying causes" or "Cross analysis," as set forth hereinafter, rather than in the main headings of immediate causes.

The plan as drawn up by the committee is not in any sense final or complete, but is presented to provide a working basis for the study of aircraft accidents from all sources.

WEIGHTING OF ACCIDENTS

Where two or more factors cause an accident, part will be charged to each; for example, in the case of an avoidable accident following an engine failure the responsibility for the accident might be considered to be equally divided between the pilot and the power plant, in which case 50 per cent would be charged to "Personnel" and 50 per cent to "Matériel." If the responsibility for the accident rested largely upon the pilot, "Personnel" would be charged with 60, 70, or 80 per cent of the accident, or even more, depending upon the degree of responsibility decided upon. Conversely in the above cases "Matériel" and "Miscellaneous" would be charged with a total of 40, 30, or 20 per cent of the accident. This same division of responsibility might be carried out under "Personnel" or other subheads. However, in the particular case cited "Errors of pilot" would be the only division of "Personnel" which could be charged with this accident. If 80 per cent of the accident were charged to "Personnel" in the above instance, then 80 per cent of the accident would be charged to "Errors of pilot." Then, assuming that the responsibility for such piloting error rested jointly upon error of judgment and poor technique, a still further subdivision would be made and 40 per cent of the accident would be charged to "Error of judgment" and 40 per cent to "Poor technique." Thus the factors of each crash could be traced down to the last subdivision under any heading and weighted in accordance with their importance.

CLASSIFICATION OF ACCIDENTS

For the purpose of comparative study aircraft accidents may be divided into groups of accidents of the same general characteristics. Accident prevention must be regarded as the primary purpose of aircraft study. Studies of accident causes point out needed remedies more clearly when they are supplemented by certain studies based upon the nature and results of the accident.

For example, in both bad landings and tail spins the principal cause is usually errors of the pilot. Statistics based upon the study of causes merely show that pilots' errors are responsible for more than half of all accidents, and the formulation of remedies for the situation appears difficult. If, however, the same accidents are classified according to their nature and results, it is found that the tail spin is the kind of accident that is by far the most prevalent among those which produce fatal consequences. It is apparent that new designs which decrease the tendency of airplanes to spin, or new training methods which increase the ability of pilots to avoid falling into spins and to recover from them quickly, will have a marked influence toward the prevention of fatal accidents.

Likewise, the study based upon nature and results indicates, in the case of collisions, that this kind of accident is third in importance among those which produce fatal results, and that these accidents are much more prevalent during winter months than in summer; and while remedies are not so obvious as in the case of tail spins some lines of attack immediately suggest themselves.

The following classifications for study of accidents according to their nature are recommended:

I. NATURE OF THE ACCIDENT

Under this head accidents are classified according to the type of accident which occurs.

1. *Class A—Collisions in full flight with other aircraft.*—This includes collisions with airplanes, balloons, or other aircraft while the colliding aircraft is at flying speed or at an altitude which permits free maneuvering. It excludes collisions (1) on the ground while taxying, taking off, or landing, and (2) in the air immediately before landing or after taking off and while the airplane is at or near its minimum flying speed.

2. *Class B—Collisions in full flight with objects other than aircraft.*—This includes collisions while at flying speed and with power plant functioning normally with trees, poles, houses, mountain sides, or other obstacles. It includes collisions with the earth or water by diving. It excludes collisions (1) on the ground while taxying, taking off, or landing, and (2) in the air immediately before landing or after taking off and while the airplane is at or near its minimum flying speed.

3. *Class C—Spins or stalls following engine failure.*—This includes spins, stalls, and all collisions with the earth while the airplane is out of control due to loss of flying speed following engine failure.

4. *Class D—Spins or stalls without engine failure.*—This includes spins, stalls, and all collisions with the earth while the airplane is out of control following loss of flying speed, with the engine functioning normally. It includes spins due to defective handling qualities of the airplane.

5. *Class E—Forced landings.*—This covers accidents while making landings necessitated by conditions which could not be overcome while in flight. Such conditions include engine trouble, loss of knowledge of the direction to the destination or the location on the map of the aircraft's position, bad weather, darkness, and exhaustion of fuel.

6. *Class F—Landing accidents.*—This includes accidents while the pilot is in the act of executing a voluntary landing. It does not include forced landings or accidents while examining a field from the air or approaching it for a landing.

7. *Class G—Take-off accidents.*—This includes accidents occurring between the time of starting a take-off to the time when full flying speed is gained and contact

N.A.C.A. AIRCRAFT ACCIDENT ANALYSIS FORM

CLASSIFICATION OF ACCIDENT

NATURE: .....

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RESULTS:

PERSONNEL: CLASS .....

MATERIEL: CLASS .....

UNDERLYING CAUSES OF ACCIDENT:

ERRORS OF PILOT: LACK OF EXPERIENCE (GENERAL: TOTAL, RECENT; SPECIAL: TOTAL, RECENT); PHYSICAL AND PSYCHOLOGICAL (DISEASE OR DEFECT: INHERENT, TEMPORARY; POOR REACTION: INHERENT, TEMPORARY)

MATERIEL FAILURES: FAULTY INSTRUCTIONS (OPERATING, MAINTENANCE); INSPECTION (MANUFACTURING, OVERHAUL, MAINTENANCE, INDETERMINATE); MATERIALS (ORIGINALLY DEFECTIVE, DETERIORATED, INDETERMINATE); DESIGN (ORIGINAL: STRENGTH (STRUCTURAL), ARRANGEMENT, AERODYNAMIC, INDETERMINATE; MODIFICATION); INDETERMINATE

IMMEDIATE CAUSES OF ACCIDENT

%		%		%	
	PERSONNEL		ERRORS OF PILOT		ERROR OF JUDGMENT
					POOR TECHNIQUE
					DISOBEDIENCE OF ORDERS
					CARELESSNESS OR NEGLIGENCE
					MISCELLANEOUS
			ERRORS OF SUPERVISORY PERSONNEL		
			ERRORS OF OTHER PERSONNEL		
	MATERIEL		POWER PLANT FAILURE		FUEL SYSTEM
					COOLING SYSTEM
					IGNITION SYSTEM
					LUBRICATION SYSTEM
					ENGINE STRUCTURE
					PROPELLER AND PROPELLER ACCESSORIES
					ENGINE CONTROL SYSTEM
					MISCELLANEOUS
					UNDETERMINED
			STRUCTURAL FAILURE		FLIGHT CONTROL SYSTEM
					MOVABLE SURFACES
					STABILIZING SURFACES
					WINGS, STRUTS, AND BRACINGS
					LANDING GEAR
					WHEELS, TIRES AND BRAKES
					SEAPLANE FLOAT OR BOAT
					FUSELAGE, ENGINE MOUNT AND FITTINGS
					TAIL SKID OR WHEEL ASSEMBLY
					ARRESTING APPLIANCES ON AIRCRAFT
					MISCELLANEOUS
					UNDETERMINED
			HANDLING QUALITIES		
			INSTRUMENTS		
			LAUNCHING DEVICES		
			ARRESTING DEVICES		
	MISCELLANEOUS		WEATHER		
			DARKNESS		
			AIRPORT OR TERRAIN		
			OTHER		
	UNDETERMINED AND DOUBTFUL				

PREPARED AND RECOMMENDED BY
SPECIAL COMMITTEE ON THE NOMENCLATURE, SUBDIVISION AND CLASSIFICATION OF AIRCRAFT ACCIDENTS
NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
JULY 17, 1928

FORM-A

Approved by Executive Committee N. A. C. A., October 3, 1928

with the ground has been lost, except those covered under other classifications, as, for instance, spins or forced landings.

8. *Class H—Taxying accidents.*—This includes all accidents which occur while the aircraft is maneuvering under its own power on land or water. It excludes accidents while the aircraft is still rolling after a landing or while it is getting up speed for a take-off.

9. *Class I—Fires in the air.*—This includes all accidents in which fire breaks out, either as a cause or result of the occurrence, while the aircraft is in flight.

10. *Class J—Carrier, platform, and arresting-gear accidents.*—This includes accidents occurring while the aircraft is landing upon or taking off from (1) the deck of a floating aircraft carrier, or (2) an elevated platform intended for the landing and taking off of aircraft, but excludes launching-gear accidents.

11. *Class K—Launching-gear accidents.*—This includes accidents during take-off in which the aircraft is assisted in gaining flying speed by the application of an external force.

12. *Class N—Structural failure.*—This includes all accidents which occur as a result of the failure, while in flight, of any part of the structure of the aircraft and which are not caused by contact with any external object.

13. *Class X—Miscellaneous.*—This includes accidents the nature of which is known but which do not fall into one of the above classifications.

14. *Class Y—Indeterminate and doubtful.*—This includes all accidents concerning the nature of which so little is known that any classification can not be intelligently accomplished.

II INJURY TO PERSONNEL

Under this head accidents are classified according to the injury suffered by personnel.

1. *Class A.*—A "Class A" injury is one resulting in the death of the individual within a period of 90 days.

2. *Class B.*—A "Class B" injury is one resulting in serious injury to the individual. Because of the difficulties of classification, the opinion of a physician should be obtained whenever possible as to whether an injury is severe or minor. When a physician is not available, the following general rules should be followed: Any injury that results in unconsciousness; any fracture of any bone except simple fractures of the fingers and toes; lacerations that involve muscles or cause severe hemorrhage; any injury to any internal organ; or any other injury that it seems probable will incapacitate the individual for more than five days should be classed as a severe injury. All other injuries should be classed as minor.

3. *Class C.*—A "Class C" injury is one resulting in only minor injury to the individual.

4. *Class D.*—Any personnel who experience an aviation accident with no personal injury shall be classified as "Class D."

NOTE.—The classification of an accident according to injury to personnel shall contain a letter for each individua in the aircraft at the time of the accident, the first of these letters representing the pilot of the aircraft. For example, in an accident where the pilot is killed, one passenger seriously injured, and the remaining passenger escapes with only minor injury the accident would be classified as a Class ABC accident. Had the pilot escaped with minor injury and both passengers been killed, it would have been a Class CAA accident.

III DAMAGE TO MATÉRIEL

Under this head accidents are classified according to the amount of damage which occurs to matériel.

1. *Class A.*—This includes all accidents as a result of which the aircraft is of no further value except for salvage of usable parts.

2. *Class B.*—This includes all accidents as a result of which it is necessary to completely overhaul the aircraft before it would be again airworthy.

3. *Class C.*—This includes all accidents as a result of which it is necessary to replace some major assembly of the aircraft before it would be again airworthy, such as a wing, fuselage, undercarriage, tail, or engine. Accidents in which damage to the engine was a *cause* and not a *result* are excluded from this category unless the additional damage warrants such.

4. *Class D.*—This includes all incidents which because of other factors come within the category of an aircraft accident and as a result of which there is only minor and easily repairable damage to the aircraft, such as a broken tail skag, wheel, bent propeller tip, etc.

5. *Class E.*—This includes all incidents similar to Class D accidents above in which there is no damage to matériel.

6. *Class F.*—"Class F" is included in this analysis only because of the interest it may have for the different organizations which may use this method of analyzing. It consists of matériel failures which did not result in an accident, and, strictly speaking, does not actually fit into an accident analysis. However, the methods here used for analyzing matériel failures which did result in accidents can as easily be applied to those which did not, and thus afford a method of studying the potential accidents, which because of other reasons did not occur, such as a successful landing after engine failure, etc.

CAUSES OF ACCIDENTS

The following classifications for the study of aircraft accidents according to their causes are recommended:

A. IMMEDIATE CAUSES OF AIRCRAFT ACCIDENTS

The following is a proposed list of immediate standard causes of aircraft accidents, with definitions where considered necessary for clarity.

I. *Personnel.*—This includes all accidents which can be traced to persons accessory to the operation of the

aircraft, either on the ground or in the air. This does not include accidents due to errors or omissions of personnel charged with the design, manufacture, maintenance, or inspection of aircraft.

1. ERRORS OF PILOT.—This includes all accidents the responsibility for which rests upon the pilot. The pilot is the actual manipulator of the controls or the individual responsible for their correct manipulation.
   (*a*) ERROR OF JUDGMENT.—This includes all accidents resulting from a decision made by the pilot which was not the best possible under existing circumstances.
   (*b*) POOR TECHNIQUE.—This includes all accidents resulting from lack of skill, dexterity, or coordination of the senses in handling aircraft controls, whether traceable to inherent inability to attain such or to infrequent flying, lack of experience in flying, lack of experience in flying under particular conditions, or in the particular type of aircraft.

   NOTE.—Judgment involves mental activity only for the purpose of arriving at decisions as to the ends to be attained and the general course to be followed.

   Technique is the physical expression of the mental decisions which have been made.

   See example on page 551.
   (*c*) DISOBEDIENCE OF ORDERS.—This includes all accidents resulting from the violation or disobedience of local or general orders or regulations or provisions of law governing the operation of aircraft, such as low acrobatics, acrobatics in aircraft not to be used for such purposes, or any other type or manner of operation specifically forbidden by orders or regulations issued by competent authorities.
   (*d*) CARELESSNESS OR NEGLIGENCE.—This includes all accidents resulting from the absence of care on the part of the pilot according to circumstances or the failure to use that degree of care which the circumstances justly demand, either on the ground or in the air, such as careless manipulation of the controls of an aircraft, failure to ascertain the amount of gasoline on board before taking off, failure to ascertain the conditions of the instruments, etc.
   (*e*) MISCELLANEOUS.—This includes all accidents resulting from errors of the pilot not accounted for above.
2. ERRORS OF SUPERVISORY PERSONNEL.—This includes all accidents the responsibility for which rests upon individuals other than the pilot who exercise control over the operation of the aircraft, such as navigators, formation section leaders, ground-operations officers, etc.
3. ERRORS OF OTHER PERSONNEL.—This includes all accidents the responsibility for which rests upon other personnel directly concerned with the operation of the aircraft, such as members of the flight and ground crews of the aircraft, aerographers, etc. It does not include accidents due to errors or omissions of personnel in connection with their duties of maintenance and inspection of aircraft.

II. *Matériel.*—This includes all accidents resulting from failures of the airplane, power plant, accessories, and launching and arresting devices, whether traceable to materials, faulty design, maintenance, or inspection.

1. POWER-PLANT FAILURE.—This includes all accidents resulting from failure or malfunctioning of the propelling system and all auxiliaries essential to its proper functioning, exclusive of instruments.
   (*a*) FUEL SYSTEM.
   (*b*) COOLING SYSTEM.
   (*c*) IGNITION SYSTEM.
   (*d*) LUBRICATION SYSTEM.
   (*e*) ENGINE STRUCTURE.
   (*f*) PROPELLER AND PROPELLER ACCESSORIES.
   (*g*) ENGINE CONTROL SYSTEM (THROTTLE ROD, ETC.).
   (*h*) MISCELLANEOUS.
   (*i*) UNDETERMINED.
2. STRUCTURAL FAILURE. This includes all accidents resulting from failures of the airplane exclusive of the propelling system and instruments.
   (*a*) FLIGHT CONTROL SYSTEM.
   (*b*) MOVABLE SURFACES.
   (*c*) STABILIZING SURFACES.
   (*d*) WINGS, STRUTS, AND BRACING.
   (*e*) LANDING GEAR.—This includes all accidents resulting from failure of the landing-gear struts and shock-absorbing gear, but does not include accidents resulting from failure of the wheels or floats attached thereto.
   (*f*) WHEELS, TIRES, AND BRAKES.
   (*g*) SEAPLANE FLOAT OR BOAT.
   (*h*) FUSELAGE, ENGINE MOUNT, AND FITTINGS.
   (*i*) TAIL SKID OR WHEEL ASSEMBLY.
   (*j*) ARRESTING APPLIANCES ON AIRCRAFT.
   (*k*) MISCELLANEOUS.
   (*l*) UNDETERMINED.
3. HANDLING QUALITIES.—This includes all accidents resulting from those peculiar characteristics of certain types of aircraft affecting their controllability while on the ground or in the air, such as marked tendency to ground loop, inability to recover from a spin, etc.
4. INSTRUMENTS.—This includes all accidents resulting from failures of instruments which were essential to operation under the conditions of the flight.

5. LAUNCHING DEVICES.—This includes all accidents resulting from failure or malfunctioning of catapults.
6. ARRESTING DEVICES.—This includes all accidents resulting from failure or malfunctioning of arresting gear not a part of the aircraft.

III. *Miscellaneous.*—This includes all accidents not accounted for above.

1. WEATHER.—This includes all accidents resulting from conditions of the weather which could not reasonably have been foreseen and avoided. (Mention may be made on the chart of contributing weather causes, as fog, gale, ice, hail, snow, rain, lightning, etc.)
2. DARKNESS.—This includes all accidents resulting from conditions due to nightfall which could not reasonably have been foreseen and avoided.
3. AIRPORT OR TERRAIN.—This includes all accidents resulting from airports or landing conditions of places which could not reasonably have been detected or avoided. (Forced landings should be charged to power plant, etc., unless report shows that a piloting error occurred in which case the accident would be analyzed accordingly.)
4. OTHER.—This includes all accidents resulting from causes not otherwise accounted for above.

IV. *Undetermined and doubtful.*

B. UNDERLYING CAUSES OF AIRCRAFT ACCIDENTS

The following is a list of standard underlying causes of aircraft accidents, with definitions where considered necessary for clarity.

I. *Errors of pilot.*—Returning to "Errors of pilot," paragraph I, subparagraph 1, above, the subdivisions of this paragraph were made according to the immediate causes of the errors attributed to the pilot, such as an "Error of judgment," "Poor technique," etc. The underlying causes of such errors may frequently be of more interest than the actual causes themselves. These causes may be defined as those elements which contributed to the pilot's mental and physical equipment at the time of the accident or to the deficiencies which existed in such equipment.

1. LACK OF EXPERIENCE.—This includes all accidents resulting from insufficient personal acquaintance with the actual conditions which had to be met under the circumstances.
   (*a*) LACK OF GENERAL EXPERIENCE.—This includes all accidents resulting from a lack of experience in the general problems of aviation, such as landing, taking off, air work, etc.
      (1) Lack of total general experience.—This includes all accidents resulting from a lack of general experience due to the fact that the individual concerned has never engaged in such work for a sufficient period of time to acquire the necessary experience to have avoided such accidents.
      (2) Lack of recent general experience.—This includes all accidents resulting from a lack of general ability due to the fact that the individual concerned has too infrequently engaged in general flying activities prior to the accident, and consequently lost the ability he had originally acquired.
   (*b*) LACK OF SPECIAL EXPERIENCE.—This includes all accidents resulting from a lack of experience in special problems of aviation, such as certain features of cross-country flying (which might, for example, require an intimate knowledge of the terrain of a certain section), carrier operations, night flying, blind flying, etc.
      (1) Lack of total special experience.—This includes all accidents resulting from a lack of special experience due to the fact that the individual had never engaged in such special problems for a sufficient period of time to acquire the necessary experience to have avoided such accidents.
      (2) Lack of recent special experience.—This includes all accidents resulting from a lack of ability in the special problems due to the fact that the individual concerned has too infrequently engaged in special flying activities prior to the accident, and consequently lost the ability he had originally acquired.
2. PHYSICAL AND PSYCHOLOGICAL CAUSES.—This includes all accidents resulting from a demonstrable disease or defect or poor reaction.
   (*a*) DISEASE OR DEFECT.—This includes all accidents resulting from a disease or defect, demonstrable by physical (including nervous system) examination.
      (1) Inherent disease or defect.—This includes all accidents resulting from a disease or defect which is not susceptible to remedy within a reasonable period of time, such as overshooting a field, faulty landings or collision because of defective vision or judgment of distance; unconsciousness; hysterical or epileptic tendency; chronic air sickness; inability to withstand altitude, etc. The history of an individual may often be necessary to determine if a disease or defect is inherent.
      (2) Temporary disease or defect.—This includes all accidents resulting from a disease or defect which is remediable and one which

may not be expected to repeat itself with undue frequency in the individual concerned, such as fatigue, either mental or muscular, staleness, temporary illness, incomplete convalescence, etc.

(*b*) POOR REACTION.—This includes all accidents which result from no demonstrable disease or defect but from psychological causes, making the individual react either erroneously or slowly to a situation, such as selecting what is manifestly the poorer of two fields for an emergency landing, persisting on a course when better judgment would indicate that he should land or turn back, indulging in acrobatics over prohibited areas or at too low altitude, etc.

(1) Poor reaction, inherent.—This includes all accidents resulting from psychological causes which apparently are not susceptible to correction within a reasonable period of time. The history of the individual would be a very important adjunct in determing if such poor reaction were inherent and its repetition to be frequently expected.

(2) Poor reaction, temporary.—This includes all accidents resulting from psychological causes which apparently are subject to correction, disciplinary or otherwise, within a reasonable period of time.

II. *Matériel failures.*—The underlying causes of "matériel failures" should also prove of considerable interest in analyzing accidents.

1. FAULTY INSTRUCTIONS.—This includes all accidents resulting from matériel failures which were traceable to errors or omissions in the standard instructions covering the use of such matériel.

(*a*) FAULTY OPERATING INSTRUCTIONS.—This includes all accidents resulting from matériel failures which were traceable to the operation of such matériel in accordance with standard instructions which prove to be incorrect or incomplete, such as instructions governing the use of the mixture control which when carried out are found to damage the engine, instructions governing the proper engine operating temperature which when carried out are found to damage the engine, etc.

(*b*) FAULTY MAINTENANCE INSTRUCTIONS.—This includes all accidents resulting from matériel failures which were traceable to the maintenance of such matériel in accordance with standard instructions which prove to be incorrect or incomplete, such as instructions governing the type of protective coating to cover duralumin parts when operating as a seaplane, etc.

2. FAULTY INSPECTION.—This includes all accidents resulting from matériel failures which were traceable to errors or omissions in the inspection of such matériel.

(*a*) FAULTY MANUFACTURING INSPECTION.—This includes all accidents traceable to faulty inspection of matériel where such errors or omissions occurred prior to the receipt of this matériel by the consumer.

(*b*) FAULTY OVERHAUL INSPECTION.—This includes all accidents traceable to faulty inspection of matériel where such errors or omissions occurred during overhaul or storage of the matériel.

(*c*) FAULTY MAINTENANCE INSPECTION.—This includes all accidents traceable to faulty inspection or matériel where such errors or omissions in inspection occurred after the final delivery of this matériel to the operating unit.

(*d*) FAULTY INSPECTION, INDETERMINATE.—This includes all accidents traceable to faulty inspection of matériel where actual responsibility for the errors or omissions in inspection can not be definitely placed.

3. FAULTY MATERIALS.—This includes all accidents resulting from matériel failures which were traceable to defective materials when such defects in materials could not reasonably have been detected and eliminated by a proper system of inspection.

(*a*) ORIGINALLY DEFECTIVE MATERIALS.—This includes all accidents traceable to faulty materials where the materials contained such defects when originally delivered.

(*b*) DETERIORATED MATERIALS.—This includes all accidents traceable to faulty materials where the defects of such materials occurred through deterioration after delivery.

(*c*) FAULTY MATERIALS, INDETERMINATE.—This includes all accidents traceable to faulty materials where it is not possible to determine the actual time or place when such defects first appeared.

4. FAULTY DESIGN.—This includes all accidents resulting from matériel failures which were traceable to errors or omissions in the original design of such matériel.

(*a*) FAULTY DESIGN, ORIGINAL.—This includes all accidents traceable to faulty design where such errors or omissions in design occurred in the original design of such matériel, or in the course of changes initiated or directed by persons having recognized authority regarding design or construction.

(1) Faulty original design, structural strength.

(2) Faulty original design, arrangement.

(3) Faulty original design, aerodynamic.

(4) Faulty original design, indeterminate.

(*b*) FAULTY DESIGN, MODIFICATION.—This includes all accidents traceable to faulty design where such errors or omissions in design occurred in modifications to the original design of such matériel initiated or directed by persons not having recognized authority regarding design or construction (such as jury rigs, emergency repairs, etc.).

5. INDETERMINATE MATÉRIEL FAILURE.—This includes all accidents from matériel failures the exact source of which can not be determined.

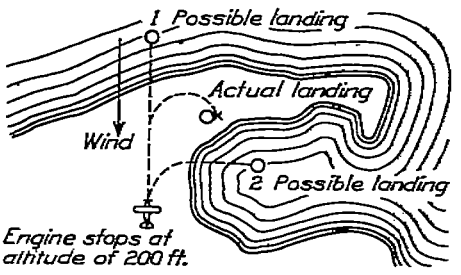
ALLOCATION OF ACCIDENTS

In compiling statistics an accident should be allocated to the service or organization having jurisdiction over or control of the operation of the aircraft at the time of the accident. In the case of collisions the accident itself should be analyzed as a single accident, but should be carried statistically by each of the organizations involved.

Injuries and fatalities should be allocated according to the aircraft in which they occur.

DESCRIPTION AND TYPICAL ANALYSIS OF AN ACCIDENT

Pilot John Doe was flying in a seaplane at 200 feet altitude over a point of land between a bay and the open sea when the engine stopped. Pilot Doe had an opportunity to land either directly into the wind in the open sea or cross wind in the bay. He started to land in the ocean, but at 100 feet altitude he changed his mind and attempted to turn so as to land in the bay. In turning, Doe held the nose of the seaplane up, stalled it, and spun into the land. The seaplane was demolished, the pilot was seriously injured, and the passenger was killed.



Doe, according to his record, was an experienced aviator with 30 hours' flying during the preceding month and with recent experience in stunting airplanes.

Examination of the engine showed that one of the teeth in the magneto timing gear had stripped, the broken tooth having been drawn into the other teeth, causing the eventual stripping of all teeth. The original break was determined to be a visible hardening crack.

The NATURE of this accident is Class C—Tail spin following engine failure, as defined on page 545. The classification according to RESULTS is Personnel, Class BA (p. 547); Matériel, Class A.

In analyzing this accident the IMMEDIATE CAUSE is charged, as indicated on the analysis chart, as 75 per cent "Personnel" and 25 per cent "Matériel," for the reason that the account of the accident shows that the pilot had two chances to make a safe landing and took advantage of neither of them. Considering the 75 per cent which is charged to "Personnel", it is obvious that this is chargeable neither to "Errors of supervisory personnel" nor to "Errors of other personnel," so that the whole weight, 75 per cent, must be placed under "Errors of pilot." It appears that the errors of the pilot involved both errors of judgment and poor technique. He first decided to land straight ahead in the ocean, which was a proper decision. Then, after reaching an altitude at which turning without power is generally considered dangerous, he decided to turn and land in the bay. This was an error and showed poor judgment. Poor technique was displayed in the execution of this decision in that the pilot continued to pull the nose up, still further stalling the seaplane, when he should have sensed the approaching stall. It is considered that a charge of 35 per cent to "Error of judgment" and 40 per cent to "Poor technique" represents as near an approximation as can be arrived at in this case.

On analysis of UNDERLYING CAUSES it would appear that the "Error of judgment" and "Poor technique" were both due to a "Temporary poor reaction" with a strong possibility of such "Poor reaction" being "Inherent" rather than "Temporary." However, in the absence of a history of the individual this would have to be classified as "Temporary."

Considering the 25 per cent charged to "II. Matériel," the entire 25 per cent obviously should be assigned to "1. Power-plant failure," in the second order of subdivision, and again in the third order of subdivision the entire 25 per cent should be charged to "(*c*) Ignition system."

The underlying cause of this matériel failure is unquestionably faulty manufacturing and accordingly on the cross analysis it would be placed under the head of "Manufacturing inspection."

INTERPRETATION OF DEFINITIONS AND METHODS

As was anticipated, questions have arisen regarding the proper interpretation of the definitions and the methods to be followed in using the proposed method of analysis. These questions have generally been referred to the committee for opinions or the interpretations followed have been communicated for approval. In this manner there has been established a sort of approved procedure.

An early criticism was the effect of the personal factor on the weights to be assigned to the various causes of an accident. That the average obtained

AIRCRAFT ACCIDENTS

N.A.C.A. AIRCRAFT ACCIDENT ANALYSIS FORM

CLASSIFICATION OF ACCIDENT

NATURE: CLASS C TAIL SPIN FOLLOWING ENGINE FAILURE

RESULTS:

PERSONNEL: CLASS B A

MATERIEL: CLASS A

IMMEDIATE CAUSES OF ACCIDENT

%		%		%		UNDERLYING CAUSES OF ACCIDENT: ERRORS OF PILOT: GENERAL: TOTAL	GENERAL: RECENT	SPECIAL: TOTAL	SPECIAL: RECENT	LACK OF EXPERIENCE: DISEASE OR DEFECT: INHERENT	LACK OF EXPERIENCE: DISEASE OR DEFECT: TEMPORARY	PHYSICAL AND PSYCHOLOGICAL: POOR REACTION: INHERENT	PHYSICAL AND PSYCHOLOGICAL: POOR REACTION: TEMPORARY	MATERIEL FAILURES: FAULTY INSTRUCTIONS: OPERATING	FAULTY INSTRUCTIONS: MAINTENANCE	INSPECTION: MANUFACTURING	INSPECTION: OVERHAUL	INSPECTION: MAINTENANCE	INSPECTION: INDETERMINATE	MATERIALS: ORIGINALLY DEFECTIVE	MATERIALS: DETERIORATED	MATERIALS: INDETERMINATE	DESIGN: ORIGINAL: STRENGTH (STRUCTURAL)	DESIGN: ORIGINAL: ARRANGEMENT	DESIGN: ORIGINAL: AERODYNAMIC	DESIGN: ORIGINAL: INDETERMINATE	DESIGN: MODIFICATION	INDETERMINATE
75	PERSONNEL	75	ERRORS OF PILOT	35	ERROR OF JUDGMENT								35															
				40	POOR TECHNIQUE								40															
					DISOBEDIENCE OF ORDERS																							
					CARELESSNESS OR NEGLIGENCE																							
					MISCELLANEOUS																							
			ERRORS OF SUPERVISORY PERSONNEL																									
			ERRORS OF OTHER PERSONNEL																									
25	MATERIEL	25	POWER PLANT FAILURE		FUEL SYSTEM																							
					COOLING SYSTEM																							
				25	IGNITION SYSTEM											25												
					LUBRICATION SYSTEM																							
					ENGINE STRUCTURE																							
					PROPELLER AND PROPELLER ACCESSORIES																							
					ENGINE CONTROL SYSTEM																							
					MISCELLANEOUS																							
					UNDETERMINED																							
			STRUCTURAL FAILURE		FLIGHT CONTROL SYSTEM																							
					MOVABLE SURFACES																							
					STABILIZING SURFACES																							
					WINGS, STRUTS, AND BRACINGS																							
					LANDING GEAR																							
					WHEELS, TIRES AND BRAKES																							
					SEAPLANE FLOAT OR BOAT																							
					FUSELAGE, ENGINE MOUNT AND FITTINGS																							
					TAIL SKID OR WHEEL ASSEMBLY																							
					ARRESTING APPLIANCES ON AIRCRAFT																							
					MISCELLANEOUS																							
					UNDETERMINED																							
			HANDLING QUALITIES																									
			INSTRUMENTS																									
			LAUNCHING DEVICES																									
			ARRESTING DEVICES																									
	MISCELLANEOUS		WEATHER																									
			DARKNESS																									
			AIRPORT OR TERRAIN																									
			OTHER																									
	UNDETERMINED AND DOUBTFUL																											

PREPARED AND RECOMMENDED BY
SPECIAL COMMITTEE ON THE NOMENCLATURE, SUBDIVISION AND CLASSIFICATION OF AIRCRAFT ACCIDENTS
NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
JULY 17, 1928

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Approved by Executive Committee N. A. C. A., October 3, 1928

from a considerable number of cases can not be far off is shown by the results from a test conducted by the original special committee, but not mentioned in its report. Six accidents were reported in identical form to each member of the committee and were analyzed independently by him. The percentages assigned the various causes were then averaged and the averages were compared with the individual ratings. Every member was willing to accept the average values as a fair analysis of the various accidents, and the differences between the values assigned by the individuals and the averages were remarkably small.

RESULTS FROM USE OF PROPOSED METHOD OF ANALYSIS

The method of analysis proposed in the report of the special committee has been in use by both of the military services—that is, the Army and the Navy—and the Department of Commerce for a little more than a year. All accidents are analyzed by this method and the results given critical study. A consideration of the results from the study of accidents which occurred before January, 1929, is of particular interest.

The three services have analyzed the accidents which occurred to airplanes under their respective jurisdictions during this period, have classified them according to nature, and have assigned responsiblity for their occurrence to the various causes. The accidents considered include 1,432 from the military services and 1,400 from civil aeronautics under the jurisdiction of the Aeronautics Branch of the Department of Commerce. No accidents to lighter-than-air craft are included. From the data provided by the individual services have been prepared the two following tables in which the average occurrence by nature and the average allocation of causes are represented by percentages:

NATURE OF AIRCRAFT ACCIDENTS IN PERCENTAGES

Classification	Number of accidents and percentages of totals		
	Army and Navy, 1,432	Civil, 1,400	Total, 2,832
A—Collisions in full flight with other aircraft	2.44	0.64	1.55
B—Collisions in full flight with objects other than aircraft	3.00	8.14	5.54
C—Spins or stalls after engine failure	1.68	5.14	3.39
D—Spins or stalls without engine failure	8.31	24.07	16.10
E—Forced landings	25.98	20.71	23.38
F—Landing accidents	32.60	17.50	25.14
G—Take-off accidents	8.17	10.93	9.53
H—Taxying accidents	5.45	2.29	3.88
I—Fire in the air	1.33	.93	1.13
J—Carrier, platform, and arresting-gear accidents	5.17	.00	2.61
K—Launching-gear accidents	1.05	.00	.54
N—Structural failure	1.61	3.00	2.30
X—Miscellaneous	2.09	4.86	3.46
Y—Indeterminate and doubtful	1.12	1.79	1.45

CAUSES OF ACCIDENTS IN PERCENTAGES

	Army and Navy, 1,434.5	Civil, 1,400	Total, 2,834.5
Pilot's error of judgment	11.44	10.22	10.83
Pilot's poor technique	26.83	29.61	29.25
Pilot's disobedience of orders	1.62	3.36	2.48
Pilot's carelessness or negligence	6.59	7.47	7.02
Pilot's miscellaneous errors	.07	.53	.30
Errors of supervisory personnel	1.64		
Errors of other personnel	1.37		
	3.01	2.32	2.67
Power plant failure	19.02	15.75	17.41
Failure of landing gear (including floats)	6.34	1.75	4.07
Failure of wheels, tires, or brakes	2.73	.52	1.64
Structural failure of other parts	3.61	3.25	3.43
Handling qualities	1.34	.34	.85
Instruments	.02	.00	.01
Launching devices	.31	.00	.16
Arresting devices	.76	.00	.38
Weather	3.44	6.92	5.16
Darkness	.15	.96	.56
Airport or terrain	8.47	5.60	7.06
Miscellaneous	.70	3.54	2.10
Undetermined and doubtful	1.47	7.86	4.62

It should be remembered that the accidents covered by this study all occurred before January, 1929. Many of them date back several years to the very beginning of the organized control of civil aeronautics and to a time when the airplanes available to the military services still included many of war-time origin. At that time possibly one-half of the pilots and airplanes, composing civil aviation and figuring in these statistics, were unlicensed and not subject to regulation by the Department of Commerce. Wooden propellers were still largely used. The systems for training civil and military pilots, while improving, were still not as good as now used, and it should not be forgotten that training accidents must always contribute largely to the statistics of airplane accidents. One of the facts brought out by the study of the accidents which have been analyzed by the military services is that of the total number of accidents 30 per cent are due to student training and 20 per cent to the training of reserves. In further analysis of the student accidents it was found that 80 per cent could be attributed to errors of personnel. Furthermore, the great development of civil landing fields and aids to navigation either had not begun or was only partly accomplished.

In view of the foregoing, the agreement between the proportions assigned by the respective services to the different natures of accidents and especially to the different causes is remarkable. It is believed that these minor differences in reality reflect the differences between the services and their demands on pilots and machines, and that in order to understand the figures of these tables, it is essential to consider the missions and conditions of operation that affected the two branches of aviation.

Consider first the tabulation under "Nature of accident." Because of the demands upon service pilots for maneuvers in formations and tactics simulating war conditions, they were naturally exposed to a greater degree to the hazard of collision with other air-

craft. On the other hand, the airports and military bases from which these pilots operated were in a large measure better suited for use and freer from obstacles interfering with the approaches than were the small fields from which so many of the civilian pilots had to fly. Hence, it is not surprising that civilian airplanes more often collided with fixed objects.

The comparisons under the heading of spins after engine failure and spins without engine failure are believed to show the influence of two factors. The difference between the figures for spins or stalls after engine failure is believed to reflect the uniformity of training programs and methods in the Army and Navy and the standardization of instruction. These naturally provided a more thorough schooling for the student than could the decentralized schools of commercial aviation, only a few of which even now conform to the highest rating of the Department of Commerce. Considering spins or stalls without engine failure, it should be remembered that military airplanes are generally higher powered than are civil airplanes. Therefore the range of speeds available to them is higher, and reserve power is available to help the pilot extricate himself from a situation which might otherwise result in a stall and subsequent spin.

Forced landings and landing accidents may be considered together. The fact that military pilots are often required to operate over open water in land airplanes, and regularly operate over the open sea in seaplanes, and the fact that military airplanes usually operate at higher landing speeds, account for the greater proportion in the military services. Furthermore, it may be doubted if the civil branch has always received full reports of such accidents, whereas in the military services, such data have been regularly required and the habit of discipline makes their supply in full detail a matter of course.

Take-off accidents can be blamed again on the poorer type of airport which often had to be used by civil flyers and upon the lower powered engines, whereas the greater proportion of taxying accidents in the military services probably reflects the crowded conditions of the landing fields prevalent during the operation of large squadrons and flights.

The figures for fire in the air are practically the same, and the only comment required is to emphasize the relative infrequence and the belief that it is growing less frequent.

Carrier, platform, arresting, and launching gear accidents have been peculiar to naval avaition. This type of equipment has not been in general use by either civil aviation or by the Army. Hence accidents of this class during the period considered were all from the Navy.

The appearance in the Army and Navy of a smaller proportion of accidents classified by nature as "Structural failure" is believed to show the value of standard specifications for materials and rigorous supervision of design and construction. However, reference to the analysis according to causes shows that structural failure figured to a larger degree in accidents in the military services than in civil aviation. This apparent conflict disappears when it is remembered that in classifying accidents according to nature the whole accident is assigned to the class to which it seems to belong, while in analyzing according to causes every contributing cause is entered and its relative weight in causing the accident is estimated. Hence accidents will appear as having the nature of "Structural failure" only when a structural failure is the outstanding characteristic and obviously major cause. However, structural failures often appear following the beginning of the trouble which produces accidents which are classified under other headings, as far as nature of accident is concerned. In these cases the analysis according to causes will show structural failure to a greater or less degree but it will not appear at all under nature of accident.

It is suggested that in addition to supervising design more closely, the military services in analyzing accidents are more apt to assign structural failure as a contributory cause than are those who analyze accidents for the Department of Commerce. Hard usage and bad landings in the military services are more apt to be considered a service condition to be regularly anticipated and to meet which the airplane must be designed. Just because of the greater demands made on the airplane and the correspondingly stricter control over design, when a structural member does give way (even though the pilot or other factors are primarily at fault), the military services consider that whenever practicable such members should be made stronger in order to avoid similar accidents in other service airplanes of the same type.

The higher figures for civil aircraft in the miscellaneous, indeterminate, and doubtful classes probably again reflect the difficulty met by the Department of Commerce in obtaining full and comprehensive reports of the mishaps.

Consider now the analysis according to "Causes of accidents." The first two items show that the judgment and technique of the pilots in military and civil aviation were about on a par, but the third and fourth items clearly show the results of discipline in the military services.

The part which miscellaneous personnel and other personnel causes played in causing accidents plainly was small in both organizations.

Power-plant failures appear to have had a larger influence in causing accidents to the military airplane than to the civil. This is to be expected, because, as mentioned above, with some types of military airplanes, often operated over the open sea, a dead engine meant almost a sure accident, while much civil flying still

consisted of relatively short flights in the neighborhood of landing fields.

"Structural failure" has already been discussed in connection with the discussion of the "Nature" of accidents. However, at this point attention is invited to the fact that failures of landing gear, wheels, tires, etc., are a regular result of operation over difficult terrain. At the same time they are decidedly minor accidents which are, no doubt, frequently not reported by the civil pilot with the particularity demanded of military personnel. This explains the marked differences in the corresponding percentages under civil and military aircraft.

Until we reach "Weather" the differences between the military and civil proportions of the succeeding items are too small to require comment.

The larger part which weather played in civil accidents might be expected. Full aerological information with special aviation weather forecasts has only recently become available to civil aircraft, and not yet to all of them, while military aircraft have had their own aviation weather service for years. Flying operations have regularly been curtailed because of the prediction of bad weather conditions. Lacking such service, civil aircraft have frequently flown into bad weather of which they had no warning, or have attempted scheduled flights with inadequate information regarding weather conditions. Some classes of civil flying, mail for instance, proceeded in the face of known weather conditions when neither military nor other civil aviation would normally be operating.

It is obvious that the personal element must enter any analysis such as this. The percentages assigned various types or causes can not be considered as absolute, but the figures do represent the fairest estimate available.

The above remarks should be kept clearly in mind, together with a thorough appreciation of the varying difficulties encountered by pilots and airplanes while meeting the requirements of operation in the two departments of aviation. It is the belief of the committee that the comparative tables may then be studied with profit.

CONCLUSION

The Committee on Aircraft Accidents believes that the practical value of the accident analysis chart prepared by the Special Committee on the Nomenclature, Subdivision, and Classification of Aircraft Accidents, and the importance of the information which may be obtained from the use of this chart, have been clearly demonstrated in its use in service in the War, Navy, and Commerce Departments.

As a result of experience, there have been introduced into the present report some minor changes in definitions and nomenclature, which changes, however, are in conformity with the classifications already set up.

Of particular interest, in the opinion of the committee, are the new data in tables and discussion relating to Nature of Aircraft Accidents and Causes of Accidents, giving comparisons between the military and civil operations. With two or three exceptions, the agreement both for Nature and Causes of Accident between the two classes of operation is noteworthy.

The committee has given careful consideration to the physiological and psychological problems involved in the piloting of aircraft as having an important bearing on the number and types of accidents which occur. In this study the committee has been ably assisted by representatives of the medical personnel of the naval flying service, the Army Air Corps, and the Aeronautics Branch of the Department of Commerce. No definite recommendations along this line have been formulated, but it is believed that the discussions of these problems in the meetings of the committee have been of considerable value to the representatives of the three services in their study of aircraft accidents in their respective organizations.

In presenting this report for publication the committee appreciates that it can not represent a completed project, as the study of aircraft accidents can never be finished. The report represents the experience of the committee and of the three departments concerned in the study of aircraft accidents up to the present time. The study of aircraft accidents for the purpose of analyzing them in such a manner as to assist in reducing their frequency and severity is a task which can never be completed, but must be continued in step with the progress of the art.

Respectfully submitted.

COMMITTEE ON AIRCRAFT ACCIDENTS,
GEORGE K. BURGESS, *Chairman.*

WASHINGTON, D. C., *January 28, 1930.*